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The Clinical Reasoning and Multi-Modal Rehabilitation Approach in a Patient with Post Concussive Syndrome Following a Moderate-TBI: A Case Study

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Abstract

Background: Prolonged and persistent symptoms following a concussion, also known as post-concussion syndrome, are becoming more prevalent in recent literature. Multi-modal treatment is widely accepted in the treatment of patients with post concussive syndrome; however, the initiation and progression of specific interventions is still debated. **Purpose:** The purpose of this case report is to describe the clinical decision-making process associated with multi-modal rehabilitation options for a patient with post concussive syndrome following a moderate TBI. **Case Description:** A 57-year-old male referred to physical therapy 2 months following a moderate-TBI and diagnosed with post-concussion syndrome. His symptoms consisted of dizziness, severe headache, cervical pain, photophobia, hyperacusis, and impaired balance. His past medical history is benign with no history of previous concussions. **Intervention:** The interventions utilized in this patient's rehabilitation can be divided into four main categories: manual therapy, postural re-education, balance interventions, and vestibular inventions. His treatment consisted of 13 therapy sessions over an 8-week period. **Outcome Measures:** Two outcome measures were utilized in this patient's plan of care, including the symptom evaluation section of the Sport Concussion Assessment Tool 5th Edition (SCAT 5) and the Berg Balance Assessment. Other objective measures included pain rating, cervical range of motion, and vestibular-ocular assessments. **Discussion:** This case study outlines a multi-modal plan of care for a patient with post-concussion syndrome. Furthermore, this case highlights the complexity and individuality associated with patients diagnosed with post-concussion syndrome.

Keywords: Traumatic brain injury, post-concussion syndrome, neurology, physical therapy, rehabilitation

Background

A mild traumatic brain injury (also known as concussion) is caused by a blow or jolt to the head that causes the brain to move within the skull. This movement can lead to axonal damage, which alters chemical connections within the brain. Full recovery from concussions typically occurs within a 10-14 day time period. However, approximately 20-40% of those who suffer a concussion may experience persistent symptoms. Post concussive syndrome (PCS) is diagnosed after 30 or more days following a concussion with persistent or worsening symptoms.[1] Common symptoms of PCS include, but are not limited to, headache, dizziness, tinnitus, blurred vision, balance impairments, fatigue, photophobia, hyperacusis, memory and cognitive impairments, feeling like in a fog, in-attention, loss of consciousness, and emotional lability.[2]

The Sport Concussion Assessment Tool 5th Edition (SCAT 5) is a popular assessment utilized to aid in the diagnosis of concussion, especially during sporting events. The on-field assessment can be completed in approximately fifteen minutes and consists of five sections, including red flags, observable signs, memory assessment, Glasgow coma scale, and cervical spine assessment. In addition, the office or off-field assessment can be utilized by clinicians to determine baseline symptom severity and obtain objective measurements to determine plan of care. The second portion of the SCAT 5 consists of five steps, including patient's background, symptom evaluation, cognitive screening, neurological screening, and delayed recall.[3] In this particular case study, the clinicians administered the symptom evaluation from the neurological screen section of the SCAT 5 to aid in clinical reasoning, while promoting in the development of the patient's plan of care.

Prolonged rest has been the primary treatment following a concussion[4], but recent studies have demonstrated the benefits of active rest beginning sooner rather than later. The most recent Concussion Consensus statement recommends that patients should rest for 24-48 hours following concussion.[2] There are experimental studies that support a short period of rest following acute concussions. For instance, Jantzen and colleagues utilized functional MRI (fMRI) to demonstrate excessive (compensatory) brain activation as a feature of concussion.[5] This suggests that the brain should be allotted time to rest post concussion as the threshold for physical exertion is lowered. What has not been scientifically established up to this point, however, is the definition of "rest" (cognitive, physical, or both) and how long it should be prescribed. Although additional research should be conducted to determine the appropriate mode, intensity and duration of exercise following concussion, the Concussion Consensus statement recommends that low intensity exercise may be initiated within the first few days following concussion.[2] It is critical that post-concussive patients returning to exercise maintain a sub-symptom threshold as to not exacerbate symptoms.[6]

When determining plan of care for a post-concussion patient, it is important to consider the various components that contribute to concussion symptoms, including cervicogenic, vestibular, psychosocial, ocular, and cognitive dimensions. A retrospective analysis conducted by van der Walt and colleagues explored how often cervical and vestibulo-ocular interventions are received during physical therapy treatments. They analyzed 147 cases of adults suffering from post-concussion syndrome. Approximately 54% of patient's received cervical treatment, while 72% received vestibulo-ocular treatment. These findings highlight the importance of cervical, vestibular and ocular assessment during the examination process and management of post-concussive patients.[7] One therapeutic intervention often utilized to address vestibular and ocular deficits in post-concussive patients is head eye vestibular motion (HEVM) therapy. A group of investigators explored whether HEVM therapy is associated with increased function and decreased symptom severity in the PCS population. With a sample size of 70 participants, the findings suggest that HEVM therapy is indeed an effective treatment method for patients suffering from chronic PCS.[8]

Although a multi-modal approach has been widely accepted in PCS rehabilitation, when to begin specific treatment interventions and how to progress them is still highly debated. The purpose of this case report is to describe the clinical decision-making process associated with multi-modal rehabilitation options for a patient with post concussive syndrome following a moderate TBI.

Case Description

The patient was a 57-year-old male who suffered a moderate traumatic brain injury. He was the fire chief for a local fire department who sustained a blow to the head as he slipped and fell off the top of a fire truck. He sustained a skull fracture and laceration superior to the left orbital. The patient was taken to a nearby hospital where he spent five nights prior to discharge home with home therapies. He received in home physical and occupational therapy for six weeks prior to his outpatient initial evaluation. His home health physical therapy interventions consisted of balance, strength and endurance training. In addition, the patient was diagnosed with posterior canal benign paroxysmal positional vertigo (BPPV) and treated with the Epley maneuver approximately one week prior to his outpatient evaluation.

The patient was referred to our outpatient neuro clinic by a neurologist with the following medical diagnoses: moderate traumatic brain injury with loss of consciousness, post concussive syndrome. He arrived at the initial evaluation with ear plugs and tinted glasses. He also requested to use a private therapy room with the door closed to aid in the reduction of noise. The patient was accompanied by his wife. He reported “extreme” sensitivity to light and sounds that worsens throughout the day. In addition, he stated he experienced constant headaches and neck pain that would worsen with increased physical or cognitive activities. The patient reported difficulty sleeping for prolonged periods of time (more than three hours) since the incident. He also reported increased difficulty with balance in which he states, “My legs feel wobbly and I have a hard time walking in a straight line.” Patient reports difficulties focusing on words when attempting to read. He also stated that he would feel dizzy at times, especially upon standing or changing positions.

Past medical history for this patient is fairly benign, consisting of hypertension, asthma, right rotator cuff repair ten years prior, and left knee arthroscopy eight years prior. The patient does not have a previous history of concussion or TBI. He lives in a ranch style home with his wife with two stairs to enter. The patient enjoys biking, hiking, walking, and weight lifting in his free time. He works full time as a fire chief, in which he typically works 40 hours per week. Furthermore, he was unable to work or drive at the time of initial evaluation due to severe PCS symptoms and increased pain. The patient’s primary goals for therapy were to return to work, drive safely with decreased symptoms, be able to play outside with his grandchildren, and resume biking/hiking with his wife in their leisure time.

Examination and Evaluation

Following the past medical history and subjective portions of the examination, the patient was asked to complete the symptom evaluation portion of the SCAT 5, consisting of 22 symptoms, for more objective measures. The patient scored 98/132 (higher scores indicate increased severity of symptoms) for the symptom evaluation section, with 21 out of 22 symptoms reported. Headache pain was rated 10/10 and neck pain was rated 9/10 upon initial evaluation. The patient demonstrated decreased step length bilaterally with inconsistent shuffling gait pattern. He utilized a single point cane in the right upper extremity due to his balance impairment. A Berg Balance Assessment was performed, in which he scored a 41/56 (lower scores indicate increased balance impairments). This score was well below the mean for his age group, placing him at a high fall risk without the use of an assistive device. Deep tendon reflexes (biceps, triceps, brachioradialis, patellar, and Achilles) were 2+ bilaterally.

Prior to examination of the patient’s cervical spine, this therapist performed the Sharp-Purser test to ensure his transverse ligament was intact, Vertebral Artery Test to determine patency of the patient’s vertebral arteries, and Spurling’s compression test in order to clear the cervical spine. All three tests were negative; therefore, a full cervical examination was completed to further assess the patient’s deficits. Cervical active range of motion was as follows: flexion 50%, extension 60%, right and left rotation 50%, right and left lateral bending 40%. All movements elicited pain. Palpation revealed significant muscle tone of cervical paraspinals, suboccipitals, levator scapulae, and upper trapezius musculature bilaterally.

Table 1 outlines vestibular tests and measures completed, along with the clinical reasoning behind them, to allow the clinician to further evaluate the patient’s deficits.

Table 1: Summary of vestibular examination completed upon initial evaluation.[9]

Objective Test:	Result:	What the test measures:	Reason for test selection:
Vertical Saccades	Impaired, consistent undershooting	Ocularmotor dysfunction, central sign	Patient reports difficulty with reading/ visual tracking
Horizontal Saccades	Impaired, consistent undershooting	Ocularmotor dysfunction, central sign	Patient reports difficulty with reading/visual tracking
VOR x 1	Impaired, increase in symptoms (dizziness) after 5 seconds	Vestibular hypofunction	Patient reports difficulty with visual tracking
VOR x 2	Not tested due to increase in symptoms and neck pain	Vestibular hypofunction	Not tested
Convergence	Impaired at approximately 25 cm (normal ~ 6 cm)	Ocularmotor dysfunction	Patient reports difficulty with reading
Smooth pursuit	Impaired	Ocularmotor dysfunction	Patient reports difficulty with reading
Cerebellar Limb Test	Not impaired	Cerebellar dysfunction	Patient reports difficulty with balance
VOR Cancellation	Not tested due to increased symptoms	Ocularmotor dysfunction, central sign	Helps to determine cerebellar dysfunction
Head Impulse Test	Not tested due to increased neck pain	Ocularmotor dysfunction, peripheral finding due to loss of VOR	Helps determine peripheral vs central (unilateral or bilateral vestibular hypofunction)
Spontaneous Nystagmus	Not impaired	Peripheral vs central vestibular involvement	Peripheral: horizontal nystagmus that stops with gaze fixation Central: nystagmus continues with gaze fixation
Gaze Evoked Nystagmus	Not impaired	Central or cranial nerve III, IV, or VI dysfunction	Determine central sign vs cranial nerve involvement
Dix-Hallpike Test	Not impaired	BPPV of posterior canal	Patient reports dizziness with positional changes

Therapeutic Interventions

The patient received 13, one-hour sessions of physical therapy over an 8-week period. Each session was conducted at a multi-disciplinary outpatient center, consisting of physical therapy (orthopedic and neuro specialists), occupational therapy, and speech therapy services. In addition to physical therapy, the patient also received occupational and speech therapy services throughout the eight-week period (up to six sessions per week between the three disciplines). Furthermore, “care conferences” were conducted weekly, which consisted of inter-disciplinary communication between the three domains discussing the patient’s progress, goals, and barriers to rehabilitation. These meetings were meant to allow changes to the plan of care, while maintaining the patient’s best interest and goals in mind.

Therapeutic interventions for post-concussion syndrome can be separated into many divisions. For the purpose of this case study, the interventions utilized will be divided into the following sub-sections: vestibular, balance, postural re-education, and manual therapy interventions. Each of the proceeding interventions were monitored utilizing the "2/10 Rule". If the patient's symptoms increased by more than 2/10 from their baseline reading (initially measured prior to the session), then the intervention is terminated until the patient's symptoms return to baseline levels.

Manual Therapy Interventions

Manual therapy interventions, consisting of soft tissue mobilizations (STM) and joint mobilizations, were utilized early to address the patient's significant muscle tone of his cervical musculature, along with his severe headache and cervical pain. Studies have suggested that soft tissue techniques are an effective treatment method in lowering pressure pain threshold levels in those with tension-type headaches.[10] Early STM techniques included soft tissue mobilizations to bilateral cervical paraspinals, levator scapulae, suboccipitals, and upper trapezius musculature. The muscle groups previously listed were addressed for an average of 1-2 minutes each with the treating therapist utilizing mild to moderate pressure. A suboccipital release technique was also utilized in increments of 4 sets of 30 seconds holds to reduce patient's increased muscle tone. In addition to STM techniques, manual stretching of the patient's upper trapezius and levator scapulae were performed bilaterally, each for 30 seconds holds.

Joint mobilizations of the cervical spine were utilized beginning with the third treatment session. The providing therapist used previous clinical experience to start with STM techniques during the first few treatment sessions, then introduced joint mobilizations as the patient became more comfortable with manual therapy interventions. The patient's joint mobility of the cervical spine was assessed and found to be hypomobile grade I at segments C2-C5 bilaterally with cervical down glides. Grade I and II joint mobilizations were utilized first during the third treatment to establish rapport with the patient. The therapist then used grade III and IV mobilizations in following treatment sessions to restore patient's cervical mobility in attempt to improve gross cervical range of motion. Manual therapy interventions were applied during the first seven treatment sessions. Over these seven treatment sessions, the patient reported an average pain reduction of 1.5 points on a 0-10 scale prior to and following STM/joint mobilizations. In addition to manual therapy, the patient was prescribed a home exercise program consisting of self upper trapezius and levator scapulae stretches performed in a seated position.

Postural Re-education Interventions

The patient presented to the initial evaluation with slightly rounded and elevated shoulders with forward head posture. Along with manual therapy, postural re-education is a critical component of PCS rehabilitation, especially in patients with hypertonic cervical musculature. The first postural re-education interventions were supine deep neck flexor (capital flexion) re-education and cervical retraction exercises given during the first treatment session. However, the patient was unable to complete deep neck flexor exercises secondary to weakness and increased head ache pain. With additional verbal cueing, patient was able to perform supine cervical retraction (2 sets of 10 repetitions), which was added to his home program. Deep neck flexor re-education was integrated in the fourth treatment session without symptom exacerbation. Patient progressed cervical retraction exercises by holding each repetition for an increased period of time. He then progressed to standing cervical retraction against a solid surface or wall, and lastly performed the exercises in a prone position (gravity resisted position).

Another area of focus following PCS is scapular alignment, stability, and control. For this particular patient, seated scapular retraction exercises were given on the second treatment session. However, the patient had extreme difficulties in activating middle and lower trapezius to perform the desired movement. Instead, he relied heavily on his upper trapezius musculature. In attempt to isolate the middle and lower trapezius, unilateral prone scapular retractions with shoulder extension was used with verbal and tactile cueing. Again, the patient was unable to complete the desired movement without upper trapezius engagement. Lastly, proprioceptive neuromuscular facilitation (PNF) scapular

techniques (scapular clock) with tactile cueing were utilized, in which the patient responded well. He even demonstrated carry-over into the following session. To progress his scapular stability, prone scapular retractions with three second holds were added during the fourth treatment session. Furthermore, he was able to progress to prone (on a physioball) scapular retraction with shoulder extension, then 90 degrees abduction, and lastly scaption to promote abdominal and scapular stabilization.

Balance Interventions

In order to further assess the patient's balance impairments, a balance error scale score (BESS) was administered at the beginning of the patient's first treatment session due to lack of time during the initial evaluation. The clinical reasoning behind this assessment was to analyze the patient's specific balance impairment and develop a treatment plan to address those specific impairments. The patient scored a 14/30 on the firm surface portion of the assessment, while tallying a score of 21/30 on a foam surface. He recorded a total BESS score of 35/60 (higher scores indicate increased balance impairments), with more difficulty demonstrated on foam versus a firm surface. According to Iverson and colleagues, the mean score for men between the ages of 55-59 is 16.4/60.[11] Thus, the patient scored significantly higher than others of his particular age group and gender.

The patient's performance on the BESS test indicated increased difficulty on compliant surfaces and conditions when the patient required increased reliance on his vestibular system (trials with his eyes closed). Therefore, the clinician selected balance interventions aimed at improving his vestibular and somatosensory systems. The first balance intervention selected for this particular patient was a modified tandem stance with up to 30 second holds. During the first treatment session, the patient was only able to maintain modified tandem stance for up to 14 seconds with his right lower extremity anterior and up to 12 seconds with his left lower extremity anterior. In addition, the patient was instructed to perform all home exercise program balance exercises at the kitchen sink or countertop if hand held assistance was needed to ensure his safety. The patient was advised to perform balance interventions two to three times per day at home.

Many balance progressions took place throughout the patient's plan of care. For instance, the patient was able to progress to higher level static balance activities after the first couple of treatment sessions. Such activities include full tandem stance and single leg balance exercises beginning on a firm surface, then standing on a more compliant surface. Furthermore, performing balance activities with eyes closed and horizontal/vertical head turns were added to further challenge the patient's vestibular system. The patient started with slow head turns, then progressed to moderate and fast speeds as he became less symptomatic and his balance ability improved. Dynamic balance activities were added to the patient's treatment plan during his 6th treatment session. Such activities included forward and backward tandem walking in the parallel bars, with horizontal and vertical head turns added as the patient's ability to perform the task improved. Another tool utilized for this patient was an Airex Balance Beam, which adds a compliant surface to more dynamic balance activities. The patient completed forward and backward tandem walking, along with lateral stepping over progressively larger cones to promote improved dynamic balance ability.

Vestibular Interventions

As illustrated by Table 1, the patient had multiple vestibular deficits affecting his ability to his perform daily tasks, including reading, driving, and performing work-related objectives. This particular patient's vestibular interventions were centered around three specific impairments: saccades, VOR, and convergence. Horizontal and vertical saccades were introduced during the patient's first treatment session and added to his home exercise program. The therapist elected to begin with saccades at this juncture of the patient's rehabilitation process as convergence exacerbated his symptoms and he had increased neck pain with any movement of the cervical spine. Using two objects (pens) held approximately 12 inches away from the patient's nose, the patient was instructed to move eyes as quickly as possible between the objects without increasing his headache symptoms. The patient began

with slow eye movements but was able to progress to moderate and fast speeds over the course of 3 weeks.

Convergence and VOR exercises were initiated on the patient's fourth treatment session. Multiple strategies were utilized to improve the patient's ability to converge on an object. The first intervention used was "pencil pushes", an exercise where the patient focused on an object (such as the tip of pencil) and moved it as close to their nose as possible before diplopia occurs. The patient was instructed to maintain his focus on the object for 2-3 seconds prior to moving the object away his from his nose. However, the patient had difficulty converging with his left eye and was unable to complete the exercise with proper technique. Pencil pushes were attempted for two more sessions, but due to the lack of success, a different approach was taken in hopes of improved results. A convergence device called the Brock string was used instead of pencil pushes. The Brock string consisted of a string with colored beads spread at various distances apart depending on the patient's ability level. Because the patient demonstrates significant difficulty with convergence, three beads spaced 3 inches apart were used initially. The patient was instructed to move from one colored bead to the next, maintaining focus of one bead at a time. He responded well to this intervention, demonstrating proper convergence technique. Therefore, the therapist elected to add the Brock string exercises to the patient's home exercise program rather than the pencil pushes.

VOR exercises were initiated on the fourth treatment session as the patient's cervical pain decreased (patient rated 5/10 on this date). The patient was instructed to hold an object 12 inches in front of his nose and focus on a single point. Then, while keeping the object still and maintaining focus, the patient would move his head from side to side. As his VOR ability improved, he was able to progress the speed of the head turns. On the 8th treatment session, he progressed to VOR x 2 (both object and head moving in opposite directions). The patient initiated each vestibular exercise in a seated position and progressed to standing as his ability improved and symptoms decreased.

Outcome Measures

The re-evaluation for this patient occurred on his 10th physical therapy visit and included objective measurements to demonstrate his improvement. Furthermore, these outcome measures are also utilized to aid in updating the plan of care as needed. He decreased his headache pain from 10/10 on initial evaluation to 4/10 upon re-evaluation. In addition, his cervical pain was reduced to 3/10 pain compared to 9/10 on his initial reading. He reduced his SCAT 5 symptom evaluation section score to 49/132 compared to 98/132 reported on initial evaluation. Moreover, 13/22 total symptoms were reported on re-evaluation compared to the initial 21/22 reported on evaluation. According to Chin and colleagues, the minimal detectable change (MDC) of the SCAT 3 for this patient's duration of PCS is 6.58 points.[12] Thus, this patient demonstrated a clinically important difference from initiating physical therapy through his re-evaluation. The patient also improved his Berg Balance Assessment score from 41/56 on initial evaluation to 49/56 on re-evaluation. With a minimal detectable change of 4.9 points for this patient's age and initial Berg score, he demonstrated a significant improvement in his static balance ability.[13]

Discussion

The purpose of this case report was to outline the clinical reasoning and progression of therapeutic interventions for an individual with post concussive syndrome following a moderate traumatic brain injury. This particular patient received a multi-disciplinary treatment approach, including physical, occupational, and speech therapy, which was conducted at an outpatient neurological center. Although the speech and occupational therapeutic interventions were not highlighted in this case, they were a crucial aspect to this patient's reduction of symptoms and overall rehabilitation. The physical therapy interventions for this case were multi-modal in nature and consisted of four main domains: manual therapy, postural re-education, balance interventions, and vestibular interventions. The progressions outlined in this case study were based on the patient's response to each intervention.

Previous literature has suggested that head-eye vestibular movement therapy (HEVM) is a beneficial therapeutic technique for those suffering from chronic PCS.[8] Furthermore, manual therapy has been indicated and shown to be effective in reducing pain pressure thresholds in those with tension-type headaches.[10] Although many studies have investigated single interventions in isolation in those with PCS, there is a limited number that have investigated a multi-modal therapeutic approach. One of the barriers to conducting these types of studies is the complexity and individuality of each case. For instance, an individual suffering from PCS may only report two or three symptoms. On the other hand, other patients may report a multitude of symptoms, which only makes investigation and rehabilitation more difficult. Another aspect of rehabilitation is the progression of the interventions utilized. Again, this ties into the complexity and uniqueness of each case.

Upon reflection, one area that could have been improved in this particular case was the management of psychosocial factors impacting the patient. The patient expressed extreme guilt for his accident during the first three to four treatment sessions, sharing statements such as, “How could I have let this [accident] happen?”. This guilt, along with the recent death of a close family member, delayed his rehabilitation potential in the early stages of therapy. The psychosocial aspect of an individual is a crucial component of physical rehabilitation. In retrospect, the therapists involved in this patient’s plan of care should have recognized the psychosocial implications to his rehabilitation, while referring to the proper healthcare provider to address this barrier, such as a neuropsychologist.

This case highlights the complexity of treating a patient with PCS and demonstrates the use of an individualized plan of care. This patient's interventions were tailored based on his specific presentation, limitations, and response to treatment. We used an approach of progressing his care based on his symptoms and objective outcome measures such as the SCAT 5, pain rating scale, and the Berg Balance Assessment. This clinical decision-making process requires a therapist to be flexible and attentive to the patient depending on their initial presentation, along with the patient’s response to various interventions.

References:

1. Barbosa RR, Jawa R, Watters JM, et al. Evaluation and management of mild traumatic brain injury: An Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg.* 2012*;*73:S307-S314.
2. McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016*. Br J Sports Med.* 2017;51:838-847.
3. Echemendia RJ, Meeuwisse W, McCrory P, et al. The sport concussion assessment tool 5th edition (SCAT5): background and rationale. *Br J Sports Med.* 2017;51:848-850.
4. Silverberg ND, Iverson GL. Is rest after concussion “the best medicine?”: recommendations for activity resumption following concussion in athletes, civilians, and military service members*. J Head Trauma Rehabil.* 2013;28(4):250–9.
5. Jantzen KJ. Functional magnetic resonance imaging of mild traumatic brain injury. *J Head Trauma Rehabil.* 2010;25(4):256–66.
6. Leddy JJ, Baker JG, Willer B. Active rehabilitation of concussion and post-concussion syndrome. *Phys Med Rehabil Clin N Am.* 2016;27:437-454.
7. van der Walt K, Tyson A, Kennedy E. How often is neck and vestibulo-ocular physiotherapy treatment recommended in people with persistent post-concussion symptoms? A retrospective analysis. *Musculoskelet Sci Pract.* 2019*;*39: 130-135.
8. Carrick FR, Clark JF, Pagnacco G, et al. Head–eye vestibular motion therapy affects the mental and physical health of severe chronic postconcussion patients. *Front Neurol.* 2017;8:414.
9. Goebel JA. The ten-minute examination of the dizzy patient. *Semin Neurol.* 2001;21(4):391-398.
10. Ferragut-Garcías A, Plaza-Manzano G, Rodríguez-Blanco C, et al. Effectiveness of a treatment involving soft tissue techniques and/or neural mobilization techniques in the management of tension-type headache: a randomized controlled trial. *Arch Phys Med Rehabil.* 2017;98(2):211-219.

11. Iverson GL, Kaarto ML, Koehle MS. Normative data for the balance error scoring system: implications for brain injury evaluations. *Brain Inj.* 2008;22:147-152.
12. Chin EY, Nelson LD, Barr WB, McCrory P, McCrea MA. Reliability and validity of the Sport Concussion Assessment Tool–3 (SCAT3) in high school and collegiate athletes. *Am J Sports Med.* 2016;44*:*2276-2285.
13. Donoghue D, Stokes EK. How much change is true change? The minimum detectable change of the Berg Balance Scale in elderly people. *J Rehabil Med.* 2009;41:343-346.